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Optical and structural analysis of copper oxide thin films

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Abstract

CuO thin films were deposited on glass substrates by spin coating method. The optical and structural properties were studied by changing the annealing temperature and molar concentrations of starting solutions. The XRD results show that the thin film samples are crystalline and are having monoclinic structure. The mean optical band gap was 3.43eV for molar concentrations ranging from 0.3- 0.5 M.

1. Introduction

Copper oxide thin films have attracted the attention of the research investigators because of their good electrical and optical properties [1-3]. The research on CuO has been mainly focussed on its catalytic, gas sensing and photovoltaic properties [4-8]. The properties of copper oxide depend on its structure, which depend upon on preparation conditions of the thin films. Copper oxide appears in two forms: CuO and Cu_2O. These are p-type semiconductors with different energy gaps [9-11]. CuO has a direct band gap of 1.3eV, which makes it an ideal material for solar cells fabrication [12-13]. Copper oxide thin films have been prepared by various methods such as sol gel, wet chemical synthesis, magnetron sputtering, pulsed laser deposition, MBE and electro-deposition [14-18]. Sol gel is the most suitable method as its relatively simple and cost effective. Also the properties of the thin films can be improved with the type and concentration of precursors as well as the annealing temperatures [19]. In this paper, the fabrication and characterization of CuO thin films by sol gel spin coating method is presented.

2. Experimental Methods

A solution of 0.46 M copper acetate power and isopropanol was taken in appropriate amounts. The solution is stirred on a hot plate stirrer for 15 min to dissolve all components. During stirring diethanolamine (DEA) and polyethylene glycol was added into the solution to get the sol. Before deposition the glass substrates were cleaned thoroughly with soap and acetone to remove any organic impurities. For the thickness measurement of the films by weight difference method, the weight of the substrate before and after thin film deposition was recorded. The films were deposited in a spin coater with a spin speed of 2300 rpm for 10 seconds. Three to five layers of the thin film on the single substrate were deposited. After each deposition, the thin film was dried at $250^{O}C$ for 10 minutes.

3. Results and discussion

(a) Thickness measurement: Thickness measurement is of utmost importantance for the thin films growth. There are various ways to determine the thickness of thin films namely:

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Microbalance technique, quartz crystal oscillator method, photometric method, ellipsometry, interferometery, absorption spectroscopy, stylus method and weight difference method.

If W_1 and W_2 are the weights of the substrate before and after thin film growth in gms, A= Area of thin film deposition in cm^2 ,'ρ' is the density of CuO given in the literature. Film thickness

$$t = \frac{w_2 - w_1}{A\rho} \times 10^4 \, \mu m$$

The thicknesses of thin films were found to be 0.18 or 180 nm. The relationship between thickness and spin speed of disk and is given by

t □ 1/□□

(b) Optical Characterization

Three different samples with different concentration of molar solutions 0.3M, 0.4M and 0.5M were prepared.

(i) 0.3M concentration of precursor concentration

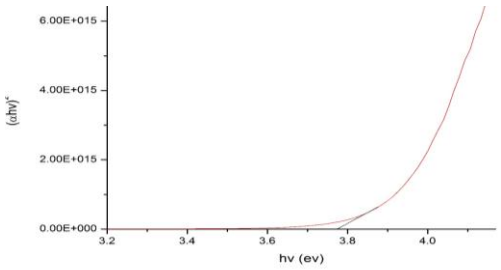

Fig. 1 Direct band gap 0.3M(3.78eV)

(ii) 0.4 M concentration of precursor concentration

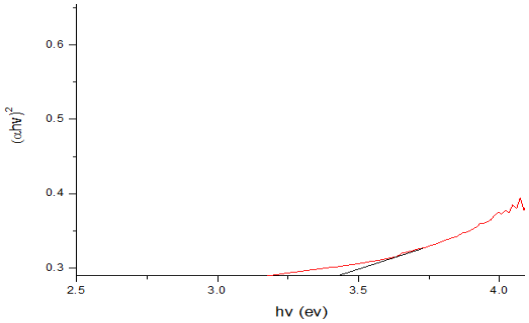

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Fig. 2 Direct band gap (0.4M) 3.4eV

(iii)0.5 M concentration of precursor concentration

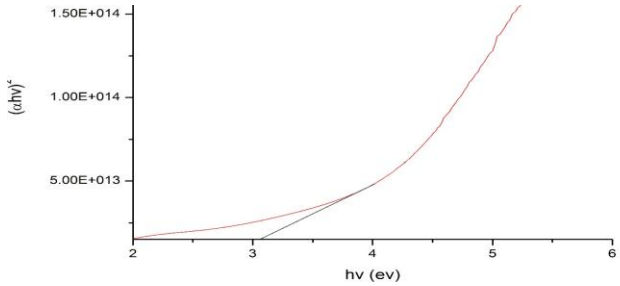

Fig. 3 Direct band gap (0.5M) 3.1eV

From the above graphs, it has been observed that the mean band gap energy for copper oxide thin films is 3.43eV lies in between 1.3-3.7eV, which agrees well with the values reported in the literature [20].

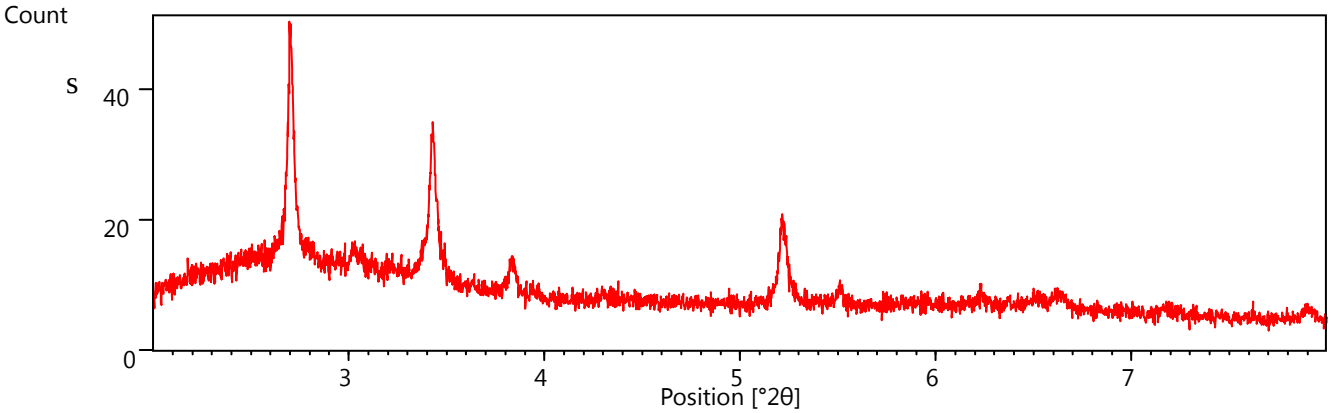

Fig. 4 The above diagram shows the XRD for a copper oxide thin film sample

Fig. 4 shows the x-ray diffractograph for the thin film of CuO. The diffraction pattern was measured in the diffraction angle range of 0-80^0. The appearance of sharp peaks indicates the presence of crystalline structure.

REFERENCES

1. F. Marabelli, G.B. Parravicini, F. Salghetti-Drioli, “Optical gap of CuO” Physical Review Vol. B52, p.1433-1436, April, 1995

2. Wei-Tang Yao, Shu-Hong Yu, “Formation of uniform CuO nanorods by spontaneous aggregation selective synthesis of CuO, Cu_2O and Cu nanoparticles by a solid liquid phase discharge process” The journal of Physical Chemistry B, Vol. 109, p.14011-14016,2005

ISSN:0971-1260
Vol-22-Issue-37-December -2019

3. F. Marabelli, G.B. Parravicini, F. Salghetti-Drioli, "Evidence of localized states in the optical gap of CuO" Physica B199-200 p.255-256, 1994

4. L. A. Patil, D.R. Patil, "Hetero contact type CuO-modified SnO_2 sensor for the detection of a ppm level H_2S gas at room temperature" Sensors & Actuators B, Chemical Vol. 120 p. 316-323, 2006

5. YunZhe Feng, Xiaolin Zheng, " Plasma enhanced catalytic CuO nanowires for CO oxidation" Nanoletters, Vol. 10, p. 4762-4766, 2010

6. C.C. Chusuei, M.A. Brookshier, D.W. Goodman, "Correlation of relative x-ray photoelectron spectroscopy shake up intensity with CuO particle size, "Langmuir" Vol. 15, p. 2806-2808, 1999.

7. Jiatao Zhang, Junfeng Liu et al., " Nearly mono dispersed Cu_2O and CuO nanospheres: Preparation and application for sensitive gas sensors, " Chemistry of Materials" Vol. 18, p. 867-871, 2006

8. P. Raksa, S. Nilphai, A. Gardchareon, S. Choopun, " Copper oxide thin films and nanowire as a barrier in ZnO dye-sensitized solar cells, "Thin solid Films" Vol. 517, p. 4741-4744,2009

9. Fei Gao, Xiao-Jing Liu, Jun-Shan Zhang, Mei-Zhou Song, Ning Li, " Photovoltaic properties of the p-CuO/n-Si hetero-junction prepared through reactive magnetron sputtering, " Journal of Applied Physics, Vol. 111, p. 084507, 2012

10. A. Chen, H. Long, X. Li, Y. Li, G. Yang, P.Lu, "Controlled growth and characteristics of single phase Cu_2O and CuO films by pulse laser deposition" Vacuum, Vol. 38, p. 927-930,2009

11. Hiroki Kidowaki, Takeo Oku, Tsuyoshi Akiyama, Atsushi Suzuki, "Fabrication and characterization of CuO-based solar cells, Journal of Material Science Research", Vol. 1, No. 1, January,2012.

12. A. Zainelabdin, S. Zaman, G. Amin, O. Nur, M. Willander, "Optical and current transport properties of CuO/ZnO nanocoral p–n heterostructure hydrothermally synthesized at

low temperature, Applied Physics A, Vol. 108,p. 921,2012

ISSN:0971-1260
Vol-22-Issue-37-December -2019

13. L. Liu, K. Hong, X. Ge, M. Xu, "Aligned CuO nanorod arrays: fabrication and anisotropic ferromagnetism", Appl. Phys. A, Vol. 115, p. 1147, 2014

14. L. Armelao, D. Barreca, M. Bertapelle, G. Bottaro, C. Sada, E. Tondello, "A sol–gel approach nanophasic copper oxide thin films", Thin Solid Films, Vol. 442, p.-4852, 2003

15. W. Wang, Z. Liu, Y. Liu, C. Xu, C. C. Zheng, G. Wang, "A simple wet-chemical synthesis and characterization of CuO nanorods", Appl. Phys. A, Vol. 76,p. 417,2003

16. V. F. Drobny, D. L. Pulfrey, "Properties of reactively sputtered copper oxide thin films", Thin Solid Films, Vol. 61, p.89–98, 1979

17. K. P. Muthe, J. C. Vyas, Savita N. Narang, D. K. Aswal, S. K.Gupta, Debarati Bhattacharya, R. Pinto, G. P. Kothiyal, S. C. Sabharwal, " A study of the CuO phase formation during thin film deposition by molecular beam epitaxy", Thin Solid Films, Vol. 324, p. 37–43,1998

18. N. Mukherjee, B. Show, S. K. MAji, U. Madhu, S. K. Bhar, B. C. Mitra, G. G. Khan, A. Mondal, "CuO nano-whiskers: electrodeposition, Raman analysis, photoluminescence study

and photo catalytic activity", Mater. Letters, Vol. 65, p.3248-3250, 2011

19. A.A. Al-Ghamdi, Waleed E. Mahmoud, S.J. Yaghmour, F.M. Al- Marzouki, "Structural and optical properties of nano crystalline NiO thin film synthesised by sol-gel spin coating method, "J. Alloys Compd. Vol. 486, No. 9-13,2009

20. Mehdi Dhaouadi, Mohamed Jlassi, Imen Sta, Islem Ben Miled, George Mousdis, Michael Kompitsas, Wissem Dimassi, "Physical Properties of Copper Oxide Thin Films Prepared

by Sol–Gel Spin–Coating Method", Vol. 6, No. 2, p. 43-50, 2018.

